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CARTRIDGE, 81MM: HE, M374 QUALITY READINESS REVIEW

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U. S. ARMY MATERIEL SYSTEMS ANALYSIS ACTIVITY
ABERDEEN PROVING GROUND, MARYLAND

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This report presents the results of a review and analysis of acceptance and quality assurance procedures used for the 81mm mortar round: HE, M374. Objective evaluation was performed where quantitative goals of the procedures are stated in the specifications; otherwise, assumptions were made and stated as to the intended goals of procedures and are so evaluated. Cost effectiveness of the procedures is also evaluated where possible. At the time this task was undertaken, the HE M374A3 had been type classified but the Technical Data Package had not received final ARRADCOM approval. (Contd on reverse)

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Because of the close similarities between major component specifications of the HE M374A2 and HE M374A3 rounds, this report applies to both models of the mortar round with significant differences in procedures being indicated. This report has been accomplished around the following: (1) review of the specifications, (2) review of the Acceptance Test Procedures, (3) review of the drawings, (4) analysis of acceptance test data, and (5) visits to the Milan Army Ammunition Plant, ARRADCOM and ARRCOM. Having accomplished these tasks, the adequacy of the quality assurance and acceptance procedures is discussed, weaknesses found in the procedures are indicated, and suggestions for improvements are given.

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CARTRIDGE, 81MM: HE, M374
QUALITY READINESS REVIEW

HE M374 HISTORY

Development of the 81mm Cartridge: HE M374 was initiated by OTCM 37241, dated 5 November 1959. Objectives for the development program were to develop a round with increased range, accuracy, and terminal effectiveness while reducing the chance of short rounds inherent with existing fin stabilized mortar ammunition. The standard 81mm HE round at that time was the HE M362 which had been standardized in 1955.

Major design changes implemented in the HE M374 were: (1) Use of an obturator band to decrease projectile yaw, (2) Elimination of the shrouded fins used on the HE M362, and (3) Use of canted fins with a cant angle (5^{o}) to induce stabilizing spin while not causing a large enough spin rate to cause undesirable flight characteristics. In January 1964 the XM374E2 was made standard A as the M374.

Later changes were made to the HE M374 and resulted in the model HE M374A2. Significant changes that resulted in the newer model were: (1) Moisture-resistant propelling charges, (2) Moisture-proof and a higher temperature ignition cartridge, (3) Reduced bourrelet (approximately .005 inch) to remedy the hang-up problem caused by moisture-proofing residue, (4) Use of a redesigned fin assembly with a different configuration of ignition flash holes, and (5) Improved packaging.

Changes were made to the M374A2 Cartridge that resulted in the M374A3 Cartridge being classified standard A in 1975. The M374A3 Cartridge was standardized with a much simpler fuze than the older M524A6 Fuze utilizing a relatively complex arming delay mechanism. The newer M567 Fuze is a point detonating fuze with the superquick and delay settings of its predecesor. Following successful development testing of the M374A3 Cartridge, approximately 300,000 M567 Fuzes were manufactured when a fuze detonated during the jolt and jumble acceptance test at Lone Star Loading Plant and a premature explosion occurred during testing at Aberdeen Proving Ground. These fuzes are currently being rebuilt by implementing the safety features tested in the nearly identical 60mm XM935E3 Fuze. Additional testing of the M567 Fuze is scheduled to verify the new safety features.

The M374A3 Cartridge uses the single base M10 Propellant rather than the double based M9 Propellant used in the M374A2 Cartridge. The M10 Propellant is cooler burning than the M9 Propellant and will therefore allow for a higher sustained firing rate and a longer tube life. However, there has been a problem of storage life associated with the same M10 Propellant used in the 90mm M67 Recoilless Rifle. This problem will be discussed in greater detail in the section covering the M205 Propelling Charge. The M374A3 Cartridge was standardized with the M195 Propelling Charge which has since been replaced by the M205 Propelling Charge. The only difference between the charges is a more rugged increment container material (felted fiber) with the newer charge. The increment configuration for the older M90A1 Propelling Charge used on the M374A2 Cartridge consists of nine increments hooked to the fin assembly. When less than

maximum charge is desired, the crew is required to unhook and remove the proper number of increments. The increment configuration for the newer M205 Propelling Charge used on the M374A3 Cartridge consists of four horseshoe-shaped increments that slip over the fin assembly boom. When less than maximum charge is desired, it is a simple matter for the crew to slip off the proper number of increments.

The M374A3 Cartridge uses a one-piece ignition cartridge/primer assembly consisting of the M299 Ignition Cartridge and M35 Primer. The M374A2 Cartridge contains a separate M285 Ignition Cartridge and M71A2 Primer connected by a flash tube. The one-piece construction is supposed to be more water resistant than the two-piece construction.

The newer M24 Fin Assembly has a cylindrical boom to which the horseshoe-shaped increments attach and a different interior geometry to house the newer ignition cartridge. The older M170 Fin Assembly contains a conical boom with hooks at both ends to which the nine increments attach. The M374A3 Cartridge uses the same M374A1 Projectile of alloy steel, carbon steel, or pearlitic malleable iron that the M374A2 Cartridge uses.

APPROACH

The efforts that went into this particular Quality Readiness Review (QRR) can be divided into three areas: (1) Review of the M374A3 TDP, (2) Visits with key personnel at ARRCOM, ARRADCOM and the Milan Loading Plant, and (3) An analysis of historical data for the M374 "family" of HE cartridges. It is because of our rather solid historical data base dating back to 1964 that this QRR differs from other QRR's. Since 1964 when the M374 Cartridge went into production, there have been improvements resulting in the models A1, A2, and finally the A3. The quality assurance and acceptance procedures have remained fairly constant during this period. In addition, a rather significant data base consisting of development testing, acceptance testing, surveillance testing, and field malfunction reports has been in formation since 1964. Other QRR's, as for the 105mm M735 Cartridge and the 155mm M549 Projectile, have been conducted during an earlier stage of the item's development. These systems have no such comparable data base as the M374A3 Cartridge, and have utilized teams of experts to examine such areas as materials, non-destructive test methods, and so on. The team concept is in fact a part of the Methodology for QRR's as developed by AMSAA. However, in light of the data base available for the M374 family of cartridges it is believed the approach used for this QRR is as adequate as the team concept in determining weaknesses of the system. Thus the M374A3 QRR has been conducted in the manner that best utilizes the relatively long-standing status of the system.

This evaluation was undertaken at the request of DARCOM Quality Assurance Directorate and the scope of work was stated by AMSAA and approved by DARCOM:

"CONCERN HAS BEEN EXPRESSED RELATIVE TO THE EFFECTIVENESS OF QUALITY ASSURANCE AND ACCEPTANCE TEST PROCEDURES FOR NEWLY MANUFACTURED AMMUNITION ITEMS. IN THIS CONNECTION, DRCQA HAS REQUESTED THAT AMSAA INVESTIGATE THE TECHNICAL SOUNDNESS OF THESE PROCEDURES AND THE FEASIBILITY OF IMPROVEMENTS IN SAMPLING PROCEDURES, INSPECTION AND TEST METHODS, UTILIZATION OF RESOURCES, DATA ANALYSIS, AND DECISION CRITERIA.

EFFORTS TO ACCOMPLISH THIS TASK FOR CARTRIDGE, 81MM: HE, M374, INCLUDE A LITERATURE SEARCH FOR DATA AND APPLICABLE DOCUMENTS RELATING TO THE QUALITY ASSURANCE AND ACCEPTANCE PROCEDURES FOR THE MAJOR COMPONENTS AND COMPLETE ROUNDS OF THIS ITEM. THESE DOCUMENTS WILL INCLUDE DRAWINGS, SPECIFICATIONS, MILITARY STANDARDS, ACCEPTANCE TEST PLANS, PROCEDURES, AND CRITERIA. VISITS WILL BE MADE TO ARRCOM AND TO A MANUFACTURING, LOADING, AND ASSEMBLY ACTIVITY TO OBSERVE AND DISCUSS WITH KEY PERSONNEL THE QUALITY ASSURANCE PROGRAM AND ITS IMPLEMENTATION. A VISIT MAY ALSO BE MADE TO A PROVING GROUND TO OBSERVE AND DISCUSS THE BALLISTIC ACCEPTANCE TEST PROCEDURES. INFORMATION CONCERNING PROGRAM PROCEDURES OBTAINED FROM THE VARIOUS SOURCES WILL BE REVIEWED, ANALYZED, AND EVALUATED. IN ADDITION, THE RESULTS OF TESTS AND INSPECTIONS WILL BE REVIEWED, ANALYZED, AND EVALUATED. BASED ON THESE, THE EFFECTIVENESS OF THE PROGRAM WILL BE ASSESSED AND EVALUATED. ALTERNATIVES TO CURRENT PROCEDURES WILL BE EXAMINED. A REPORT WILL BE PREPARED TO DOCUMENT THE RESULTS OF THE STUDY AND ANY PERTINENT RECOMMENDATIONS."

Having received this request, a large-scale literature search was first conducted for both the M374A2 and M374A3 Cartridges and their major components. At the time this task was undertaken the A3 model cartridge was classified as Type A but no procurement had been conducted and the Technical Data Package had not received final ARRADCOM approval. The evaluation is based upon acceptance procedures for both the M374A2 and M374A3 Cartridges. These procedures are in fact nearly identical, and any differences judged to have significant impact are pointed out. All acceptance testing data will naturally be from the A2 model cartridge and its major components. The following table lists the major components of each cartridge considered in this evaluation.

Cartridge	HE M374A2	HE M374A3
Projectile	M374A1	M374A1
Fin Assembly	M170	M24
Ignition Cart	M285	M299
Primer	M71A2	M35
Fuze	M524A6	M567
Increments	M90A1	M205

The literature search encompassed Military Specifications for the items listed above, proving ground Acceptance Test Procedures, drawings, Military Standards as referenced in other literature, acceptance testing records, and requirements documents from the development phase. The search for development requirements documents yielded only OTCM 37241 (5 Nov 59) that initiated development of the M374 Cartridge and OTCM 37906 (Nov 61) that re-oriented the project and recorded the approved Military Characteristics. It had been hoped that a quantitative reliability requirement could be found in development documents and compared to actual values obtained from acceptance testing, but the reliability requirement stated only that the M374 have a reliability "better than or equal to" the existing HE M362 round.

Visits were made to the Milan Army Ammunition Loading Plant, ARRCOM, and ARRADCOM to discuss the M374 program with those involved in it. The M374A2 has not been manufactured since January 76 and there were no manufacturing lines set up for the M374 in the Milan Plant (nor in the Kansas and Lone Star Loading Plants). However, informative discussion was held with the Government Product Assurance element familiar with the M374 program. Two organizations within the ARRCOM Product Assurance Directorate were visited: the Munitions Production Quality Operations Division that covers an item through procurement and the Surveillance Operations Division that covers an item after procurement. The visit to ARRADCOM was in the evaluation's later stages of completion and was made to discuss certain topics and to generally coordinate our recommendations with those involved with the M374A3 TDP.

The final area that was considered for this evaluation was the acceptance testing of the cartridge and its major components. Picatinny Arsenal has formed a computer data base for all acceptance testing attribute data of the M374A2 Cartridge. This was utilized for the evaluation of the M374A2 Cartridge. For the major components of the M374A2 Cartridge that undergo a ballistic acceptance test, the latest firing records were analyzed and attribute summaries are included.

This evaluation is based, then, on the following: (1) A review of applicable specifications, drawings, and Acceptance Test Procedures, (2) An analysis of acceptance test data and malfunction reports, and (3) Discussion with persons at ARRADCOM, ARRCOM, and Milan Army Ammunition Loading Plant.

DISCUSSION OF FINDINGS

The conclusion of this evaluation must be that the HE M374A3 Cartridge is a very good system and its quality assurance procedures are adequate to maintain the generally high quality levels of the previous M374 Cartridge family. The newer M374A3 design has demonstrated a longer maximum range than the M374A2 design, and it is most probable that configuration changes made to the increments and fin assembly of the original M374A2E1 Cartridge will result in a higher sustained firing rate. The newer design has the inherent capability for a higher firing rate because it uses the cooler burning M10 Propellant rather than the M9 Propellant of its predecessors. However, the use of M10 Propellant in the newer design does cause us some concern. Our experience with the same M10 Propellant used in the 90mm M67 Recoilless Rifle is that it does have significantly lower shelf life than normal. The single-base M10 Propellant (nitrocellulose) has been more susceptible to deterioration in storage, particularly to changes in moisture content. The other existing problem area of the cartridge is the safety of the new M567 Fuze. The relatively small sample size utilized in the Product Improvement Test of the M374A2E1 Cartridge did not reveal this problem, but it was only later in the manufacture and acceptance testing of an initial lot that the problem surfaced. The M567 Fuze is currently undergoing a redesign with a follow-on retest planned. As the M567 Fuze utilizes a much simpler design than the older M524A6 Fuze, production costs should be significantly lower for the newer fuze.

A rather involved section of this report covers the topic of specifying defective rates or defect rates in item specifications. The older specifications written prior to April 74 allow for either type of requirement, so long as the contractor is consistent in his plan. The main point stressed in the special section dealing with the topic is that the two plans are inconsistent with one another as far as outgoing quality levels, and in general the defect rate requirement will allow lower quality levels to be accepted than the defective rate requirement. Since April 74, Picatinny Arsenal has gone to a system whereby only defect rates are specified. This change eliminates the problem of inconsistent acceptance plans, but we believe that only the defective rates should be specified. The very real danger in specifying only defect rates is that when specifications are written and defect rates are assigned, it is not easy to assess the impact of these values on the outgoing quality level of assemblies - and to a much greater degree - the end item itself.

Those rare instances of fin separation and breakup with their resulting short rounds are cause for concern, but successful steps have been taken for the M374A2 to reduce the frequency. These same steps will be taken with the M374A3. The primary cause for fin failures has been eutectic melting caused by improper heat treatment. This problem was reduced by tightening the heat treat procedures in the TDP.

A second cause of fin failures has been cracking, and this problem is now controlled by 100% visual inspection under 4 power magnification. The least frequent cause of fin failures has been a double threading of the internal fin assembly thread. This is caused by machine operator error where the threading operation is unknowingly repeated, thus removing too much material and making the fin assembly vulnerable to separation from the projectile during flight. For this third area of fin failure, there has been no corrective action taken. Our recommendation is to repeat the one submitted by Picatinny Arsenal some time ago, that 100% inspection be conducted with a thread no-go gage. The inspection time for using a no-go gage would be small, and in light of the defect's effect on performance would seem to be very worthwhile. This recommendation submitted by Picatinny Arsenal was reportedly turned down by Frankford Arsenal.

Other specific recommendations apply mainly to the M374A3 Cartridge specification and the M205 Propelling Charge specification. These recommendations are discussed in sufficient detail in the text and are summarized in the section, "Conclusions and Recommendations." There is a general comment that should be made concerning the specifications themselves. In October 1972 an AMSAA report entitled, "Analysis of Ballistic Acceptance Test Sampling Plans and Methodology" was published. One of the findings reads as follows: "Each (acceptance) test plan seemed to be an entity within itself without any overall rationale or philosophy. While such a philosophy may exist for acceptance testing, it was not readily apparent." This evaluation yields the same general impression. As a rule, reliability requirements for those parameters measured during acceptance testing do not exist (such as fuze functioning rate, low order burst rate, etc.). The specifications normally only include a test sample size with an acceptance criterion. Thus the basis for a test plan is unknown, and there is no quantitative control over a test plan. Even more alarming, though, is the lack of consistency that sometimes results in relaxation of a performance requirement. Although few performance requirements for the M374 Cartridge family have been quantified, each later model was supposed to be at least equal to its predecessor for a given performance requirement. An example of such a relaxation is where the M374A2 Cartridge has a tighter range standard deviation required than the M374A3 Cartridge. No recommendation for correcting this general type of problem is being offered here, but it is enough of a problem to warrant concern.

In conclusion, we believe the M374A3 Cartridge to be based on a solid design with performance advantages over its predecessor. The quality assurance procedures are so similar to those of the proven M374A2 Cartridge that an equally reliable system in the M374A3 Cartridge should result. We feel that those recommendations implemented from this report can only make the M374A3 Cartridge that much better than its predecessor.

HE M374A2/A3 CARTRIDGES

Because of the close similarities between the specifications and quality procedures of the M374A2 and M374A3 Cartridges, the discussion that follows applies to both cartridge models unless exceptions are noted.

The first topic to be discussed is the requirement for range standard deviation at low and high zones for the cartridges. The A2 Cartridge has a requirement that Zone 1 range standard deviation not exceed 20 meters and Zone 9 range standard deviation not exceed 50 meters. The A3 Cartridge has the same standard deviation values required except that zones 0 and 4 are specified. Aside from ignition cartridge propulsion (Zone 0), the A2 Cartridge has nine zone levels while the A3 Cartridge has four. The requirements also state that if the calculated sample standard deviation times .75 (.79 for the initial sample size of 80) exceeds the requirement, the lot is rejected. The .75 factor should be .74 to maintain the same risk level as established by the .79 factor for sample size 80. A sample size of 50 was reduced to 48 in March 73 for the A2 Cartridge, and the corresponding risk factor was evidently not corrected. As the A3 Cartridge also uses a sample size of 48, its risk factor should also be corrected to .74. The factors - .74 for the normal 48 sample and .79 for the initial sample of 80 - are used to minimize the chance that a sample range standard deviation exceeds the requirement while the lot standard deviation does not. Or in other words, these factors are fixing the probability of rejecting good material at a level of .01. This value (.01) is known as the producer's risk. The other parameter usually considered in forming a sampling plan is the consumer's risk or the probability of accepting some unacceptable level of quality. It is not possible to tell if consumer's risks were considered in any of the sampling plans studied since no unacceptable quality levels are given from which to calculate the probability of acceptance. It is doubtful that consumer's risks were considered per se in structuring the sampling plan, but it appears to be loosely based on MIL STD 105D. There are no AQL's specified for functioning failures such as failures to fire, duds, prematures, etc.; there are only sample sizes specified and accept-reject criteria. It seems a mistake not to have such an important quality characteristic as ballistic functioning controlled by specified parameters. Preferable parameters are both consumer's and producer's risks, but even AQL's stabilize the sampling plans and provide some basis for evaluation. When no parameters are specified with which to form a sampling plan, the door is open to changes which may result in unacceptable acceptance risks. An example of what can happen, though in this case the effects are not particularly harmful, was in March 1973 when the sample size was reduced from 50 to 48 cartridges because they are packaged in multiples of three. The rejection criterion was unchanged.

A problem exists in the A3 Cartridge range standard deviation requirement for Zone 0. As stated earlier, the A2 and A3 Cartridges both have a range standard deviation requirement of 20m for Zones 1 and 0 respectively. However, Zone 1 for the A2 Cartridge has a maximum range of 1001 m. while

Zone 0 for the A3 Cartridge has a maximum range of only 454 m. As the range standard deviation depends upon range, this amounts to a degradation tion in range performance for the newer cartridge. The 20 m. requirement may not be appropriate for Zone 1 on the A3 Cartridge, either, because this translates to a maximum range of 1633 m. The answer probably lies in a new standard deviation requirement for the A3 Cartridge that will result in quality at least equal to the A2 Cartridge.

There was a relatively large variation in the size of lots tested from Dec 72 to July 76. Two hundred sixteen (216) lots were produced by three manufacturers; lots ranged in size from 1064 to 122,989 with a mean of 34,840 rounds. It is in the interests of cost effectiveness and statistical sensitivity to fabricate lots as large as possible while maintaining homogeneity. Restrictions listed in the specification for cartridge lot size state that components (except for propellant) have only one interfix number and be made by only one manufacturer. Propellant may only be used from one lot number. It is recommended that a restriction be placed on the number of fuze lots that can make up a cartridge lot. Such a restriction would make it easier to trace affected cartridges when a fuze lot is suspended. It seems reasonable to restrict the fuze lots allowed in a cartridge lot to two lots.

There are other causes that tend to limit cartridge lot size. When production is just beginning, lot sizes are kept small so that testing can be accomplished to detect any initial production defects. Also, during the Vietnam period when demand for the cartridge was high, lot sizes were made smaller so that acceptance testing could be accomplished and lots fielded in a shorter period of time. The following table lists lot sizes for lots produced from Dec 72 to July 76.

Table I

Distribution of Cartridge Lot Sizes

Lot Size Interval	Frequency
1 - 10,000	34
10,001 - 20,000	52
20,001 - 30,000	29
30,001 - 40,000	28
40,001 - 50,000	21
50,001 - 60,000	17
60,001 - 70,000	10
70,001 - 130,000	25 (evenly distributed)

The A2 Cartridge specification includes an initial production test plan and acceptance criteria. There is no such plan included in the A3 specification. The test plan includes simulated trailer and aircraft transportation vibration, a five foot drop test from random orientations, two 14 day temperature-humidity cycles outlined in MIL STD 331 (test #105), and finally a ballistic test. Unlike regular acceptance testing, there are no rejection criteria for duds. This is undoubtedly because the rounds (60/group) are temperature conditioned to -40°F, 70°F, and 125°F while rounds fired during acceptance testing are all fired at 70°F conditioning. It seems that a dud rate rejection criterion should be formulated for the 70°F portion of the initial production test, though. Other functional defects considered during regular ballistic acceptance testing (standard deviation, prematures, metal parts failures, failures to fire, and short rounds) do have rejection criteria placed on them for the initial production test.

Looking at the results of ballistic acceptance testing from Dec 72 thru July 76, 216 lots were tested as manufactured by Milan, Lone Star, and Kansas loading plants. Six lots were initially rejected but three were later accepted on waiver. The lots finally accepted scored 4 duds, 5 duds, and range standard deviation exceeding 50m. at Zone 9, respectively. The lots finally rejected scored 4 duds, 5 duds, and range standard deviation exceeding 20 m. at Zone 1, respectively. As those lots finally rejected appear to have quality levels identical to those lots accepted on waiver, no trend in accepting materiel on waiver is discernable from this final acceptance record.

The following table lists attribute data for the 213 A2 Cartridge lots finally accepted in percent defective.

	One Increment	Nine Increments	Combined
Dud Rate	1.26	1.71	1.48
Misfire Rate	0.02	0.04	0.03
Low Order Burst Rate	0.04	0.02	0.03
Range Std Deviation (meters)	13.3	40.8	

The procedures used in ballistic acceptance testing are generally adequate. The Acceptance Test Procedures cover all testing/data requirements outlined in the specification. The Acceptance Test Procedure also includes necessary steps in testing such as firing warmer/spotting rounds to insure accurate data. All required data are being recorded on the acceptance testing firing records.

A particularly progressive quality program as explained by the Milan Loading Plant is the roving inspector plan outlined in the QA Pamphlet DRSAR-P-702-107. The plan provides an efficient method of monitoring manufacturing and inspection processes used in assembling this and other munitions. Assembly and inspection stations are first weighted as to relative importance to one another. The stations are then monitored by Government Product Assurance personnel whereby random, unannounced checks are made of the inspection/assembly methods being conducted at the stations. The frequency of checks to particular stations is affected by the weighting factors assigned each station. The plan provides for an excellent means of monitoring processes with a possible base of application tion covering many facets and commodity items of government procurement.

Although there is no Initial Production Test in the M374A3 Cartridge specification, there are other nonballistic tests used in the acceptance of the M374A3 Cartridge. Testing for cavitation in the HE filler is performed by X-ray. Some HE filler voids, depending upon location and type, can cause an in-bore detonation. As all HE filler voids are now classified as major defects, it is recommended that those defects that can result in an in-bore detonation be reclassified as critical defects. Another test is used to check the heat weld process of the obturator ring to the projectile. After a maximum production interval of 350 cartridges, an obturator ring is welded to a fixture and removed to insure the weld strength requirement is met. There is also a test for deterioration of of ignition cartridges. Any ignition cartridges accepted a minimum of two years before their assembly to cartridges must also be sampled to insure no deterioration. Other tests include those to determine assembly torques of the fuze, ignition cartridge, and fin assembly to the cartridge body. It is believed that adequate non-ballistic testing is being performed for the cartridge.cartridge.

M524A6/M567 FUZES

Acceptance procedures for the M524A6 and M567 Fuzes are, not surprisingly, larger in scope than those procedures applied to other components. The complexity of the fuze relative to the other cartridge components and safety considerations are reasons that these procedures are more lengthy. In general, the procedures were judged to be thorough and correct.

One difference between the acceptance procedures of the M524A6 and M567 Fuzes is in the functional acceptance test plans. The older fuze uses a rigid sample size of 150 fuzes per lot with rejection on five or more failures. The newer fuze specification allows for reduced sampling after the first three lots are accepted; initial testing is for 125 fuzes per lot with rejection on three or more failures followed by 80 per lot with rejection on two or more failures. No prematures are allowed in any of the test plans. The newer acceptance plan will result in better average quality being accepted but at higher consumer's and producer's risks because of the smaller sample size. As no requirements are listed in the specifications as to the outgoing quality levels desired, it is difficult to evaluate the plans on this basis. However, sampling plans that allow for reduced testing after a specified number of lots have been accepted from larger sample sizes are generally more cost effective than fixed sampling plans and in this respect the newer sampling plan is preferable. Operating characteristic curves for these sampling plans are included in a later (O-C) section.

There is a total of nineteen tests utilized for acceptance of the M567 Fuze and all but three of these are non-ballistic. Aside from the functional ballistic acceptance test already covered, there is also a ballistic arming delay test where twelve inert cartridges per lot are fired against a plywood screen set up 200 feet from the mortar. One or more early fuze functionings is the criterion for rejection of the entire lot. The third ballistic test is an arming test where eighty (80) inert cartridges set at superquick and delay (40 each) are fired at ambient and -40^{o}F temperatures, respectively. Of the sixteen non-ballistic tests, the jolt and jumble test and transportation vibration test simulate rough handling and transportation motions. Sample sizes for these two tests are thirty (30) for the first three lots of a contract followed by ten (10) per lot. The other non-ballistic acceptance tests are the following: spring embrittlement (5 spring types, 20 each per lot), freedom of latch test (100%), selector cap torque test (100%), slider assembly functional test (100%), slider cavity functional test (100%), critical check test (100%), leak test of front body assembly front section (12/lot), leak test of front body assembly rear section (12/lot), latch shear test (30/lot), detonator push-out test (100%), leak test of rear body assembly (12/lot), selector ring push-out test (30/lot), lead cup sleeve push-out test (30/lot), and the retainer plug torque test (20/lot). The acceptance plan appears to be quite adequate for the M567 Fuze, with the numerous non-ballistic tests insuring proper functioning and safety to the user.

The only aspect of the plan questioned is the necessity of firing forty (40) rounds at ambient temperature for the arming test. The forty (40) rounds fired at -40°F provide data not furnished through other testing, but the ambient temperature portion of the arming test appears redundant with the ballistic functional acceptance test. It is recommended that the ambient temperature portion of the arming test be eliminated.

Ballistic acceptance testing data were evaluated for 59 M524A6 lots manufactured from July 74 through July 75. Lots ranged in size from 11,056 to 159,222 and five lots were initially rejected because of excessive duds. For two lots five duds were observed in each and were finally rejected; three lots were accepted on waiver after six, six, and seven duds were observed, respectively. Again the rationale for final acceptance of initially rejected lots is unclear. Average lot size was 49,769. Accepted lots had a dud rate of 1.36%, rejected lots 3.87%, and overall 1.52%. These rates compare closely with the rates observed during acceptance of the cartridge.

In conclusion, the acceptance procedures for the M567 Fuze appear to be very complete and also cost effective, in that there is a relatively large amount of non-ballistic testing conducted to insure both quality and safety.

M90A1/M205 PROPELLING CHARGES

The quality procedures for both the M90A1 and the newer M205 Propelling Charges appear to be complete, although in some respects quite different. As was pointed out previously, the M374A3 Cartridge was type classified with the M195 Propelling Charge but later replaced by the near-identical M205 model with its different increment container material.

The older M90A1 Propelling Charge has a velocity and standard deviation test requirement for both Zones 1 and 9, where the newer M205 Propelling Charge has a similar test requirement for only Zone 4 (max charge). This reduction in the test requirement is acceptable, for both propelling charges have separate propellant assessment tests performed to determine proper loading weights to attain required velocity values.

The reduced testing for the M205 Propelling Charge still does insure proper pressure-velocity values are attained in the increment configuration. Even though maximum muzzle velocity is up from 856 to 879 fps with the newer propelling charge, it does not seem that the increase in the velocity standard deviation requirement from 3.4 to 4.0 fps is justified. In other words, a three percent increase in the maximum muzzle velocity does not appear consistent with an eighteen percent increase in the velocity standard deviation requirement. It should also be pointed out that while all other standard deviation requirements encountered in this study were adjusted by factors for producers' risks of .01, the M90A1 Propelling Charge's velocity standard deviation requirement was adjusted for a producer's risk of .05.

For both propellant types, exact loading weights are determined by propellant assessment. Three different groups of propellant weights are fired with inert projectiles whose weights are carefully controlled. A plot of propellant weight versus velocity is then used to determine exact loading weights for each propellant lot. Underweight increments in the propelling charge specifications are classified as critical defects, while overweight increments are classified as major defects. The M90A1 Charge has a tolerance band of +4 to -2 grains around the assessed weight, while the heavier M205 Charge has a tolerance band of plus or minus 8 grains around the assessed weight. It is believed that the unbalanced tolerance band is a much better method of controlling propelling charge weight because of the difference in defect classifications between overweight and underweight propelling charges. It is therefore recommended that an unbalanced tolerance band be adopted for the M205 Propelling Charge weight, say from +11 to -5 grains around the assessed weight.

Procedures for loading the M90A1 Charge into increment bags begin by weighing the increment bags and sorting them into weight groups. Increment bags are then loaded to gross weights as determined by the increment bag weights and propellant assessment. Increments are then weighed 100% and re-weighed by different operators 100% for gross weight.

Finally, 315 increment samples per lot have the propellant removed from the increment bags and the propellant is weighed. The lot is rejected if one or more samples are underweight or if three or more samples are overweight.

Procedures for the newer M205 Propelling Charge are the same except for the following difference. Instead of sampling 315 increments from the total lot, sampling is accomplished at the rate of four per 500 increments loaded. If one or more increments is underweight, or if two or more are overweight of the four weighed, the 500 increment quantity represented by the sample is rejected. The loading of increments is a very good application for a continuous sampling plan, but the rejection criterion of the M205 Propelling Charge's continuous sampling plan is extremely loose and therefore of no real value in attaining the quality levels desired. It is therefore strongly recommended that this rejection criterion for the M205 Propelling Charge be changed to one that will afford adequate protection; as stated it is totally inadequate.

Other tests are performed to insure the quality of the M205 Propelling Charge. A residue test is conducted on a portion (175 rounds) of the First Article Sample to determine if there is enough residue build-up to cause mortar round hang-ups in the mortar tube. To clarify the following tests, it must be remembered that the M90A1 Propelling Charge is encased by moisture proof cloth bags while the M205 Propelling Charge is encased by nitrocellulose shells. A leak test is conducted on all M205 Propelling Charge increment shells to insure material continuity (i.e. no cracks or voids). The leak test is performed by subjecting the increment shells to an internal pressure of 5 psi (air or nitrogen) and then evaluating the back pressure of the test equipment to insure there is no leaking. A stability heat test is performed on five increment shells per lot to determine if heat (134^{o}C) causes any instability. And finally, chemical composition tests are performed on five increments per lot. With the exception of the continuous sampling plan for propellant weight, it is believed these tests, in conjunction with the velocity and propellant assessment tests, adequately assess the quality of the M205 Propelling Charge.

As mentioned previously, the M90A1 Propelling Charge uses the double-base M9 Propellant (nitroglycerine and nitrocellulose) while the M205 Propelling Charge uses the single base M10 Propellant (nitrocellulose). Our experience with the same M10 Propellant used in the 90mm M67 Recoilless Rifle has shown that it does have significantly lower shelf life than normal. A single base propellant has a greater affinity for water than a double base propellant; however, binders used in single base propellants other than the M10 have proved effective in overcoming this inherent weakness. This potential problem with the M205 Propelling Charge will require close attention from the Stockpile Reliability Program.

M170/M24 FIN ASSEMBLIES

Neither the M170 nor the newer M24 Fin Assemblies utilize ballistic acceptance testing, nor is such testing judged to be necessary. There are ample physical property and non-ballistic tests to warrant ballistic testing as unnecessary. There have been problems with the M170 Fin Assembly due to improper heat treatment (cracks) and improper forging (eutectic melting), but steps were implemented into the TDP that have significantly reduced the frequency of fin failure. These steps involve 100% visual inspection for cracks (under 4X magnification) and a microetch inspection to insure no eutectic melting.

Both fin assemblies require an initial production sample of fifteen assemblies be submitted for inspection and metallographic test and inspection. Physical property tests (hardness and yield strength) are conducted for acceptance of all lots in addition to the metallographic inspection mentioned above. Acceptance procedures for both fin assemblies appear to be adequate.

A recommendation is being offered to correct the third, least frequent cause of fin failures. Double threading of the internal fin assembly thread is a cause of fin breakaway, and occurs when a machine operator mistakenly threads the same fin assembly twice. Since the threads are internal, the present visual inspection is not adequate in detecting this condition. This recommendation was offered by Picatinny Arsenal in the past, but was turned down by Frankford Arsenal: that all fin assemblies be checked for double threading by a no-go gage. As fin separation can be catastrophic because of the resulting short round, and as inspection by a no-gage involves minimal inspection times, it is believed the recommended inspection can improve quality with very little additional cost.

M285/M299 IGNITION CARTRIDGES

The acceptance procedures for the M285 and M299 Ignition Cartridges are similar and judged to be quite adequate. Propellant weight for the M9 Propellant filler is determined by assessment: inert rounds are fired at three different propellant weights to determine the correct weight that will deliver a projectile velocity of 215 fps. The final determination of required velocity and velocity standard deviation is evaluated through a velocity test. This test utilizes MIL-STD-414 (sampling by variables) with provision for reduced sampling after the first three lots of a new contract have been accepted. The use of MIL-STD-414 and the provision for reduced sampling are both in the interests of eliminating unnecessary testing. As the M35 Primer is integral to the M299 Ignition Cartridge, there are tests for functioning sensitivity, non-functioning sensitivity, and reliability deterioration of the primer included in the M299 Ignition Cartridge specification. Where the M35 Primer has been accepted a minimum of two years before its assembly to the ignition cartridge, the primers are sample tested to insure no reliability degradation. These same tests are conducted for the M285 Ignition Cartridge, except that the M71A2 Primer is used with this ignition cartridge. Inspection for proper propellant weight is conducted by sampling of 315 cartridges per lot, with one underweight or four overweight cartridges being cause for rejection of the lot. The M299 Ignition Cartridge also contains an alternate method of propellant weight determination: subtracting parts tare weight from the cartridge gross weight. This second method of inspection is non-destructive, and because of the inherent variability in the parts tare weight does justifiably require 100% inspection.

Other checks for adequacy of the ignition cartridges include a moisture content analysis of the black powder at the time of assembly. A burst strength test is conducted on a sampling basis to insure no bursting under a specified compressive load and to insure bursting under a higher specified compression. The M299 Ignition Cartridge also utilizes a 100% inspection pneumatic leak test to check for material continuity.

Acceptance testing data were evaluated for the period Dec 73 through May 75. Quality was excellent, as all 42 lots produced by two manufacturers were accepted. There were no ignition failures and the average velocity was 209 fps with a standard deviation of 0.67 fps. The velocity requirement is for the mean to be 200 to 220 fps and the standard deviation to not exceed 2.4 fps.

In conclusion, the acceptance procedures for the M299 Ignition Cartridge appear to be improved over those of the older M285 Ignition Cartridge. This is based on the addition of a leak test and the alternate non-destructive method of determining propellant weights. As the older M285 Ignition Cartridge has demonstrated such a high quality level during acceptance testing, it is safe to say that such quality will continue.

HE M374A1 PROJECTILE

The same HE M374A1 Projectile is used on both the M374A2 and M374A3 Cartridges. The projectile may be manufactured from any of three different materials (alloy steel, carbon steel, or Pearlitic malleable iron), but all production has been of alloy steel. Pearlitic malleable iron (PMI) yields the best fragmentation pattern, but the significantly higher acquisition cost has outweighed its performance advantage.

There are separate acceptance procedures for the three types of projectile material, but they are in fact very similar. One major difference is in the magnetic particle procedures; Pearlitic malleable iron requires 100% inspection where the other two materials allow for sampling after 2500 consecutive projectiles of a contract have been successfully inspected. This difference is because PMI is cast where the other two materials are forged and less susceptible to material defects. A second major difference in acceptance procedures is that PMI requires 100% ultrasonic inspection while carbon and alloy steel require none at all. It should be pointed out that the effects of material defects in mortar rounds are not of the same order as those encountered in artillery rounds. Because of the relatively thick walls and mild stresses to which the mortar projectile is subjected, it stands a much less risk of metal parts failure than most artillery projectiles.

Other tests of the mortar projectiles do provide protection against material discontinuities and structural failure. There is 100% hydrostatic testing (500 psi for 5 sec) and 100% air pressure testing (150 psi for 15 sec). There are also the more routine tests for material physical properties: Brinnel Hardness testing of all projectiles followed by yield strength testing on the hardest and softest projectiles of each lot. Provision is also made for an Initial Production Test where 50 rounds are fired at excess and service pressures; 20 additional rounds are sent to Picatinny Arsenal where the above tests are conducted and complete dimensional inspections are performed. Production lot acceptance testing is conducted on a sample of 20 projectiles that is fired at normal service pressure (10 each) and excess pressure (10 each).

Ballistic acceptance testing data were evaluated for projectiles manufactured from Feb 70 through June 73; the 57 lots were all made of alloy steel and all were accepted.

The rather involved procedures for establishing material defect standards for the projectile should be discussed. The specifications state the following relating to material defects: "The body, including the cavity shall be free from cracks, splits, bursts, cold shuts, piping, porosity, inclusions, folds, seams and other metal defects." This specification clause is in fact relaxed after a contract is awarded through the following steps. The TDP states that "standards will be established" and contracts now specify a 90 day time limit for the initiation of the standards. Within this 90 day period a meeting is

called by the contracting officer for the contractor and government representatives to discuss the ground rules for how the standards will be established. The variables in establishing standards are the contractor's manufacturing methods and his selection of projectile material. Having determined the manufacturing methods and projectile material, the appropriate government technical agency is in a position to use analytical techniques to establish standards. If the combination of manufacturing methods and projectile material have been previously utilized in an older contract, then the same standards would apply. It should be pointed out that these procedures are different than those utilized in the empirical determination of critical flaw size. The determination of critical flaw size utilizes testing and therefore considerably more expense. Also, critical flaw size is not practical where the choice of a different projectile material or manufacturing process will change its value. The application of critical flaw size must be for a specified material composition and manufacturing process.

The next phase of establishing defect standards for the M374A1 Projectile does not take place until manufacturing begins. It is reportedly very difficult to describe defect types and their acceptable sizes and configurations in writing, and attempts to establish standards through photographs have not been successful. As material defects are encountered at the initiation of manufacture, some are selected by the government for use in a "standards board." The standards board is a display of defect types to be used by inspectors; initially the standard states that "this condition or better" is acceptable. The standards board is refined as more defects are encountered until a "this condition or worse" rejection criterion is developed. Should a repeat contract be awarded where the same manufacturing methods and material content is used, the same standards board would apply.

This system of establishing material defect standards has been questioned in the past; particularly by the government legal offices involved with such contracts. Proponents of the system answer that it is the "practical" solution and add that although the contractor may argue against a particular standard during the establishment of the standards, in practice the contractor finally agrees to those standards established by the government rather than have the "no defects" clause of the specification invoked. The recommendation being offered here is that the methodology for establishing the defect standards be incorporated into the TDP. In this way a prospective contractor may at least judge whether he can meet the standards without waiting until he is awarded the contract and finding he is incapable of meeting the defect standards.

As mentioned above, the contractor is given some freedom in his selection of projectile material (PMI, 1340 steel, or carbon steel) and manufacturing process of the M374A1 Projectile so long as the round meets the physical property requirements specified in the TDP. However,

AMSAA has recently conducted an effectiveness comparison of several M374A1 alternative materials and manufacturing processes that indicates that fragment size and number (and thus lethality) are very dependent upon projectile material and the manufacturing process selected. M374A1 Projectiles made of 1340 steel using a hot-cold-cold-draw process are considerably less lethal than the same alloy using a hot-cup-cold-coin process; lethality can vary as much as 25 to 30 percent.

The TDP and acceptance plan for the 60mm M720 Projectile deserve discussion because they offer a possible solution to the problem of controlling projectile lethality. The M720 Projectile body material is restricted to the manufacture of 1340 steel according to the drawing (dwg #11751151) and a minimum yield strength is also specified for the finished projectile. The miliary specification (MIL-P-48400A) restricts the forming of the projectile body to cold-working; stress relief procedures are also specified and there is a micro-structure requirement for 90 percent minimum spheroidization. The M374A1 Projectile manufactured from 1340 steel utilizes these same manufacturing controls as the M720 Projectile except for the spheroidization requirement. These manufacturing controls are reportedly utilized for both projectiles to improve fragmentation properties and hence lethality.

The acceptance procedures for the M720 Projectile go one step further in that there is a fragmentation requirement in the military specification for fragment weight distribution. There are three fragment weight intervals with a minimum/maximum fragment quantity specified for each weight interval. The first three stress relieved lots of a contract require that a sample of five projectiles be fragmented in a pit test to determine the fragment weight distribution. If these fifteen projectiles meet the required fragment weight distribution, then sampling is reduced to three projectiles for each stress relieved lot. A stress relieved lot may typically contain 7,000 projectiles. There will reportedly be a clause in M720 contracts to terminate the contract if the fragmentation requirement is not met; however, the Government would still be obligated to purchase those projectiles already manufactured. There is also a First Article Test specified in the M720 military specification for arena fragmentation of seven projectiles. Arena testing would also provide the spacial distribution of fragments but there is presently no requirement in the military specification for a specific spacial distribution. Besides the additional cost of arena testing - $6,000 versus $1,000 for pit testing - the more significant drawback for arena testing is the time required for Aberdeen Proving Ground to schedule and conduct the tests and to analyze the data. The minimum time for this is two months while it can easily take twice this long where scheduling priorities delay the start of testing. Since the purpose of this testing is to monitor on-going contracts with the possibility of contract termination, a quick return fragmentation test is needed.

The manufacturing controls utilized for both the M374A1 and M720 Projectiles are reportedly specified to control lethality, and in the case of the M720 Projectile, to provide guidance to the contractor as

to how to meet the fragmentation requirement. However, for the M720 Projectile we believe that there is some inconsistency in specifying a projectile material with manufacturing controls and then imposing a performance (fragmentation) requirement. It is our opinion that a manufacturer should be free to use any projectile material and manufacturing process he chooses so long as the fragmentation requirement is met and there is no significant decrease in the projectile's operational safety characteristics. A drawback for specifying a fragmentation requirement, already evident for the M720 Projectile, is that some prospective manufacturers will be afraid to bid on a contract and risk eventual contract termination. If mobilization production quantities are required, this could be a serious problem.

In conclusion, we believe that lethality is an important performance characteristic that should be controlled by the acceptance procedures. There appears to be two viable methods of controlling lethality: strict control of material and manufacturing processes without a fragmentation requirement or the specification of a fragmentation requirement without dictating material and manufacturing processes. The first alternative would necessitate comprehensive testing and evaluation to determine which materials and manufacturing processes should be specified. The expense for this testing would be considerable. Our recommendation for the M374A1 Projectile would be to implement the second alternative: specification of a fragmentation requirement without dictating material and manufacturing processes. Contracts could contain incentive clauses to reward manufacturers that produce projectiles with superior fragmentation characteristics; if attractive enough, these incentive clauses may spur manufacturers to develop improved materials and manufacturing processes that increase lethality.

DEFECTS VERSUS DEFECTIVES

In the quality assurance system for the M374 Cartridge, two methods of material acceptance are utilized. One is a group sampling plan (defective items) and the other is an individual defect sampling plan. Since the primary concern of the consumer, in this case the US Government, is to maintain an acceptable quality of material, a measure which is commonly used for comparison is the average outgoing quality (AOQ). The point of this discussion is to show that a group sampling plan results in a lower AOQ defective rate than do the individual plans.

Prior to April 1974, item specifications written by Picatinny Arsenal allowed the choice of a group sampling plan or an individual defect sampling plan. Usually this choice was at the discretion of the procuring activity; however, a few specifications delegated the choice to the contractor, which is very risky. Specifications written after this date would allow only individual defect sampling plans. Prior to discussing each type plan in detail, we need to briefly examine the military specification document.

Military specifications first divide an item into assemblies with their respective defect types. These defect types are then grouped, within assemblies, according to categories (critical, major, or minor). In those older specifications where a choice of the group sampling plan is allowed, AQL's are specified for the different defect categories. Major defect AQL's may range from 0.40% to 1.5% while minor defect AQL's may range from 0.65% to 2.5%. Critical defects require 100% inspection.

In a group sampling plan, all defects detected during inspection for each defect type of the assembly are combined. Any item with one or more defects is classified as defective. The acceptance criterion as determined by MIL-STD-105 or MIL-STD-1235 is then applied to the number of defective items.

For an individual defect sampling plan, each defect type is evaluated separately. The AQL's for the individual plan are adjusted to 0.40% for each major defect and 0.65% for each minor defect.

The M374A2 Cartridge specification will be used here to compare the two plans because it allows for both types of sampling plans. For the finished cartridge, there are 13 different defect types within the major defect category and an AQL of 1.5% is specified for the group sampling plan. Each of the 13 defect types is assigned an AQL of 0.40% for the individual defect sampling plan. Assume a lot size of 30,000 cartridges and normal, level II inspection of MIL-STD-105. If a lot of cartridges is submitted to this individual sampling plan which has a true defect rate of 0.26% with respect to each defect type, then each defect type has a 0.99 probability of acceptance (See Table I). However, the probability that the cartridge lot will be accepted for all 13 defect types is $(0.99)^{13} = 0.88$ (See Table II). This probability of acceptance is fixed whether each defective cartridge has no more than one defect ([0.26%] [13] = 3.38% lot defective) or whether each defective cartridge has 13 defects,

one of each defect type (0.26% lot defective). Since the expected total percent lot defective is $[1-(1-0.0026)^{13}]$ 100% = 3.33%, one should expect, on the average, between one and two defects per defective.

The group sampling plan is more sensitive to the above defect distribution and results in a better average outgoing quality than the individual sampling plan. Using a group plan and an AQL of 1.5% for major defects, a lot which is 3.38% defective (no more than one defect per defective) would have a probability of acceptance (See Table III) of only 0.50 (from MIL-STD-105) as compared to 0.88 for the individual plan. For the case where each defective item has 13 defects (0.26% lot defective), the group plan has a probability of acceptance of 1.00. Realistically, the former case where no more than one defect is observed per defective is the much more typical one. As for the average outgoing quality, which is the product of the total percent lot defective times the lot probability of acceptance, the group plan's AOQ is 1.73% as compared to the individual plan's AOQ of 2.93%. (See Figure 1).

The apparent reason for requiring individual defect sampling is that experience has shown that, for a given item, there are usually only a few (one or two) predominant defects. Under the group plan, these defects could occur at a higher rate than that allowed by the individual plan and still be acceptable. It is contended that individual plans offer another advantage in that they ease inspection along the production line, reduce paper work, and probably reduce inspection costs. However, when compared against the lower outgoing lot percent defective rates that occur (particularly for major defects) for group plans, it is believed that these advantages are not worthwhile. It is recommended that both types of plans be incorporated. That is, control individual defects and lot defectives. This could be accomplished by requiring, for each component or inspection station, a group sampling plan and require that no individual defect occur more than a specified frequency.

TABLE I

Individual Plan Probability of Acceptance For Each Defect Type

Single Sampling MIL-STD-105D

Normal Inspection

Sample Size Code Letter M

AQL 0.4%

n = 315 AC = 3 RE = 4

True Percent Defective for Each Defect Type (P_i) 100%	Probability of Acceptance For Each Defect Type if Submitted to Above Sampling Plan P(A)
0.2%	0.9961
0.4%	0.9611
0.6%	0.8770
0.8%	0.7537
1.0%	0.6135
1.5%	0.3037
2.0%	0.1238
2.5%	0.0442
3.0%	0.0143

TABLE II

Individual Plan's Lot Probability of Acceptance

True Percent Defective for Each Defect Type (P_i) 100%	Total Percent Defective of Lot $P_T = [1-(1-P_i)^{13}]$ 100%	Probability of Acceptance of Lot $[P(A)]^{13}$
0.2%	2.6%	0.9505
0.4%	5.1%	0.5970
0.6%	7.5%	0.1815
0.8%	9.9%	0.0253
1.0%	12.2%	0.0017
1.5%	17.8%	0.0000
2.0%	23.1%	0.0000
2.5%	28.0%	0.0000
3.0%	32.7%	0.0000

TABLE III

Group Plan Probability of Acceptance

Single Sampling MIL-STD-105D

Normal Inspection

Sample Size Code Letter M

AQL 1.5%

n = 315   AC = 10   RE = 11

Percent Defective of Submitted Lot (P_i) 100%	Probability of Acceptance of Lot if Submitted to Above Sampling Plan, P(A)
0.5%	1.0000
1.0%	0.9996
1.5%	0.9912
2.0%	0.9456
2.5%	0.8307
3.0%	0.6525
3.5%	0.4547
4.0%	0.2826
5.0%	0.0809

CONCLUSIONS AND RECOMMENDATIONS

- The Acceptance Test Procedures based on the specifications and written by the proving grounds are generally complete.

- Inspection acceptance should be based on the number of defective assemblies and not on the number of individual defects detected.

- The "Roving Inspector Plan" outlined in QA Pamphlet DRSAR-P-702-107 provides an excellent method of process control in loading plants.

- Tailor ballistic sampling plans to the quality and risk levels desired. These missing parameters would lend consistency to the test plans.

- There is a trend in the newer specifications (M374A3 vs M374A2) to implement reduced sampling after a consecutive number of lots have been accepted. This trend should be continued in the interest of cost effectiveness.

- Specific recommended changes for the M374A3 Cartridge specification are as follows:

  *Adjust the charge 0 range standard deviation requirement to a level at least as strict as that used in the older M374A2 specification.

  *Restrict the number of fuze lots comprising a cartridge lot to two.

  Test.

- Specific recommended changes for the M205 Propelling Charge specification are as follows:

  *Adjust the velocity standard deviation requirement to a level at least as strict as that used in the older M90A1 specification.

  *Replace the balanced tolerance band for propellant weight with an unbalanced band around the assessed propellant weight.

  *Replace the propellant weight sampling plan with one affording better consumer protection.

- A specific recommended charge for the M24 Fin Assembly is as follows:

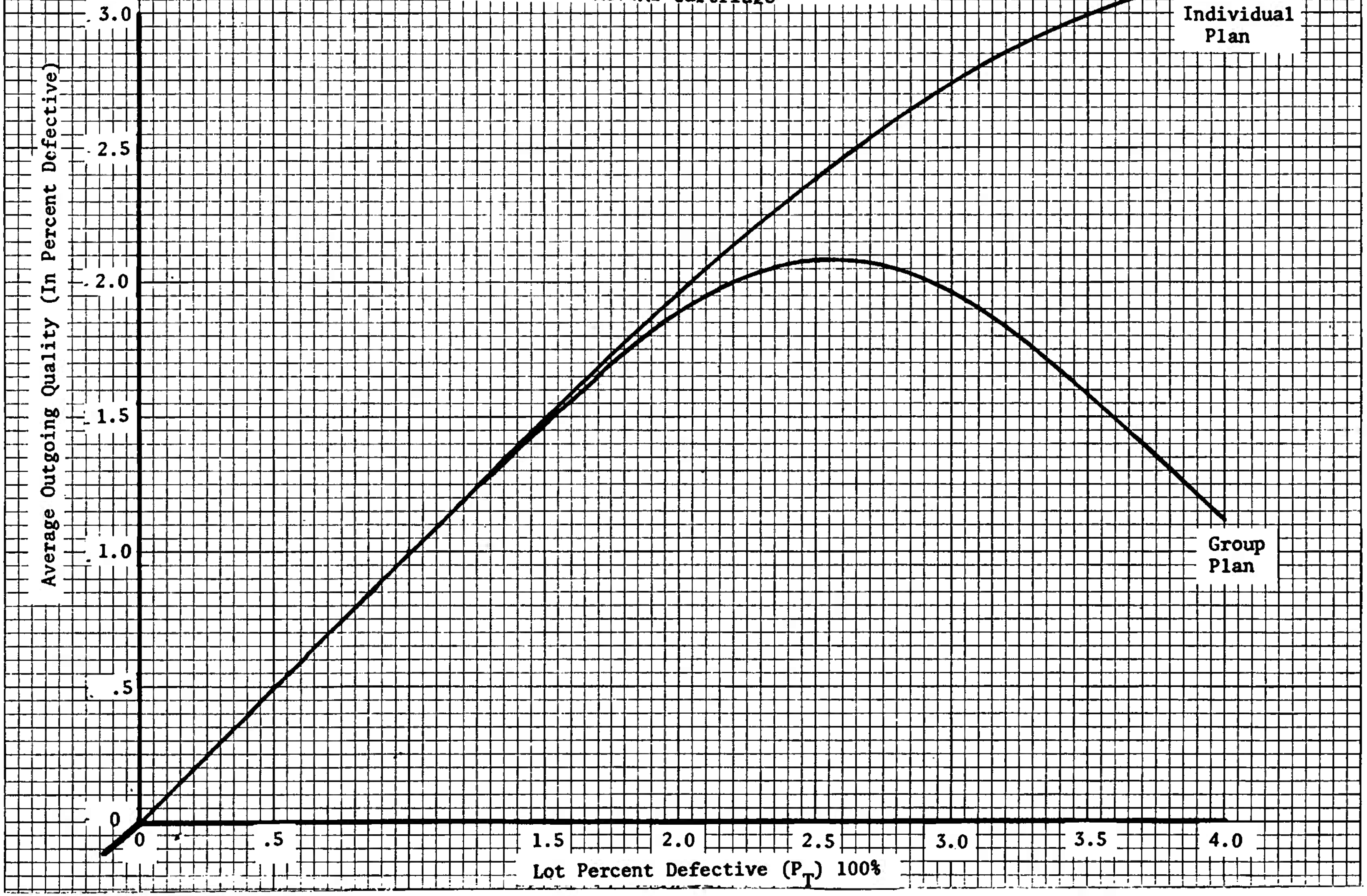
  *Implement 100% no-go gage inspection of the internal thread.

- A specific recommended change for the M374A1 Projectile is as follows:

  *Implement a fragment weight requirement in the TDP and verify production by functional fragmentation pit testing.

FIGURE 1

Comparison of Average Outgoing Quality
For Individual vs. Group Sampling Plan
M374A2 Cartridge



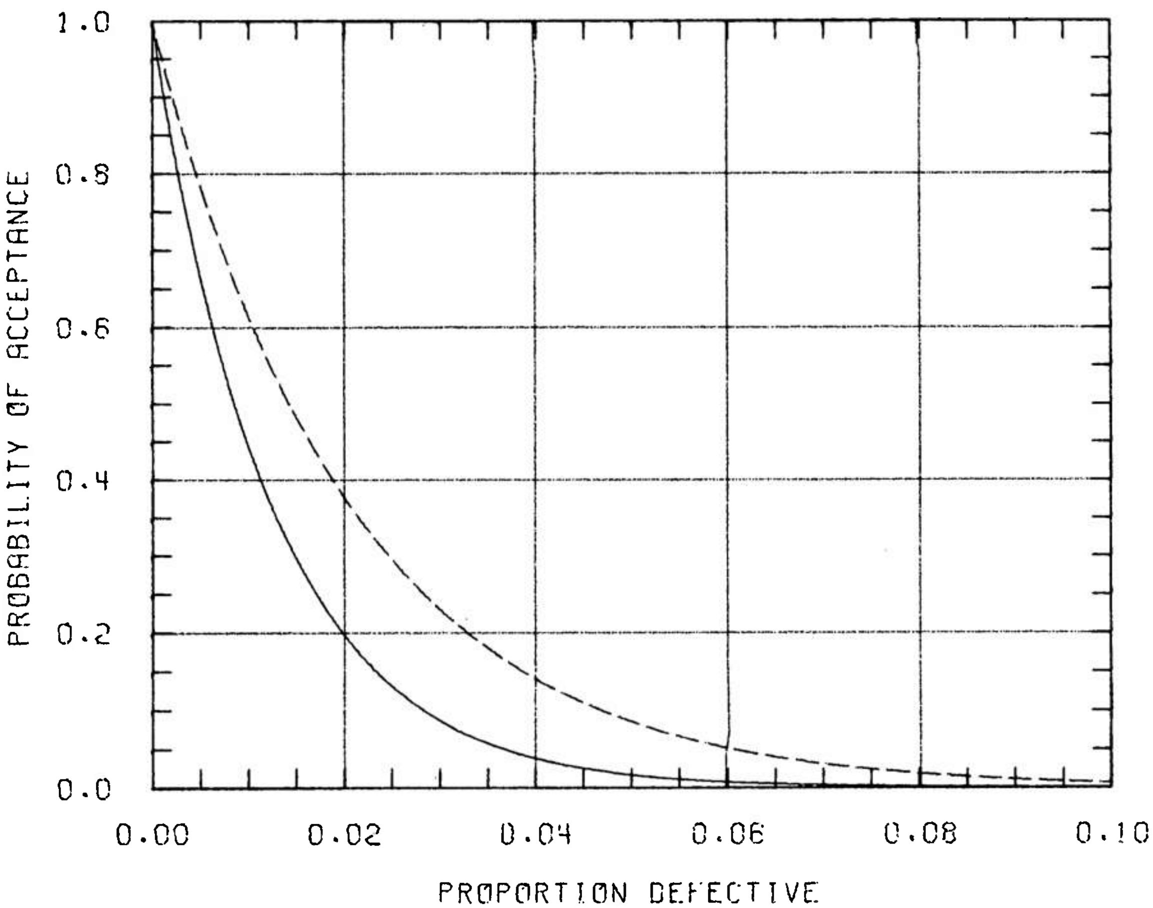
O-C Curves

I. HE M374A2/A3 Cartridges

A. Defect Type - Safety (short rds, metal parts failure, prematures)

B. Sampling Plan - First three lots of a contract sample 80/lot, then 48/lot (reduced level only if first three lots are accepted)

C. Acceptance Criterion- No defects



O C CURVES BINOMIAL DISTRIBUTION

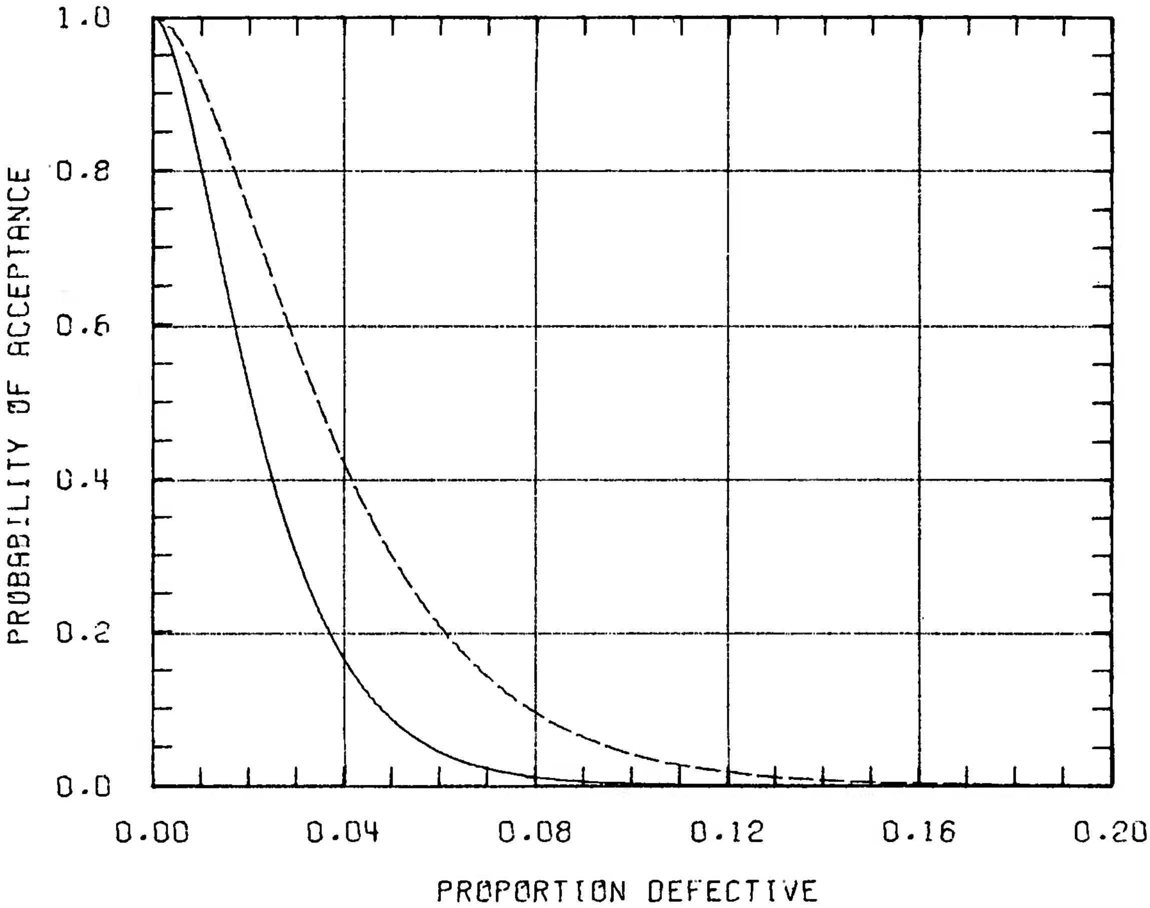
SAMPLE SIZE	FAILURES ALLOWED	LINE TYPE
80	0	————
48	0	— — — —

II. HE M374A2/A3 Cartridges

A. Defect Type - Failure to fire

B. Sampling Plan - First three lots of a contract sample 80/lot, then 48/lot (reduced level only if first three lots are accepted)

C. Acceptance Criterion- One or less defect



O C CURVES BINOMIAL DISTRIBUTION

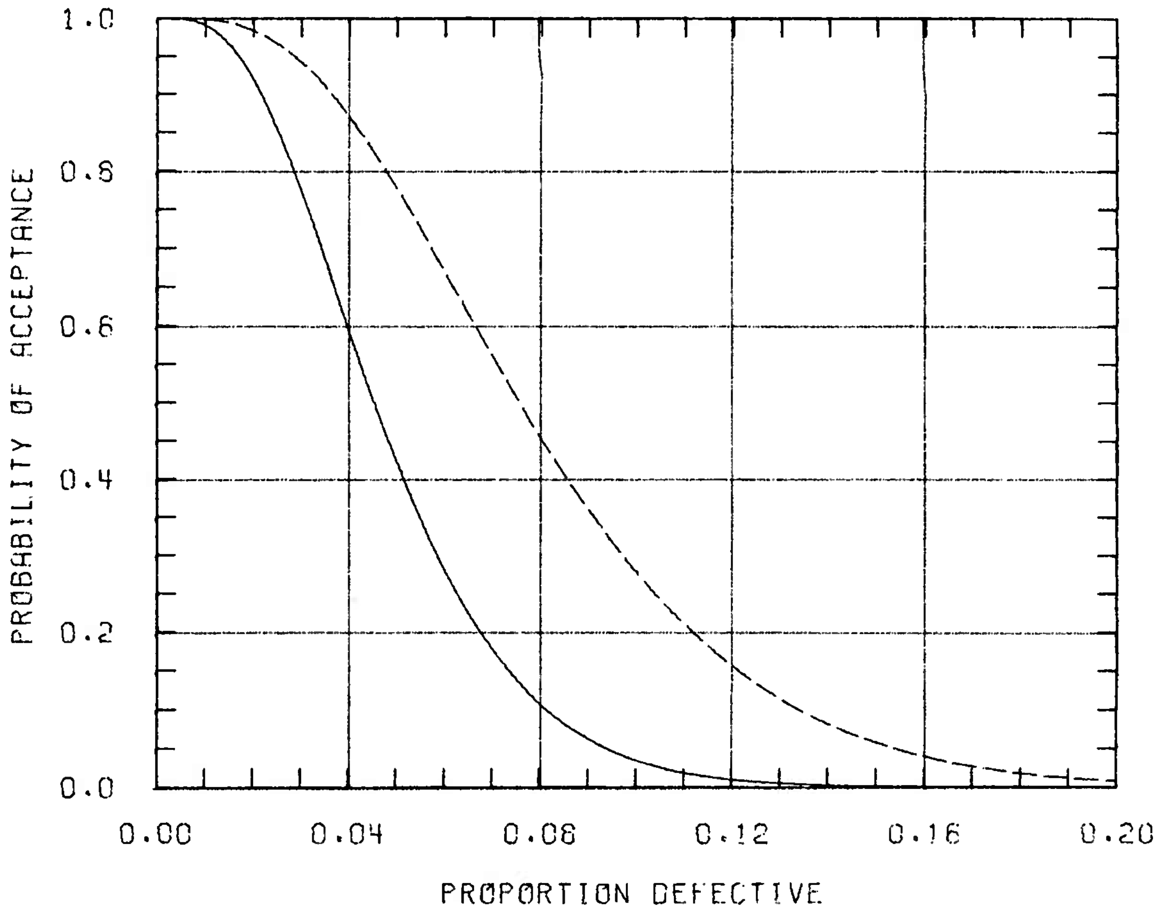
SAMPLE SIZE	FAILURES ALLOWED	LINE TYPE
80	1	————
48	1	– – – –

III. HE M374A2/A3 Cartridges

A. Defect Type - Duds

B. Sampling Plan - First three lots of a contract sample 80/lot, then 48/lot (reduced level only if first three lots are accepted)

C. Acceptance Criterion - Three or less defects



O C CURVES BINOMIAL DISTRIBUTION

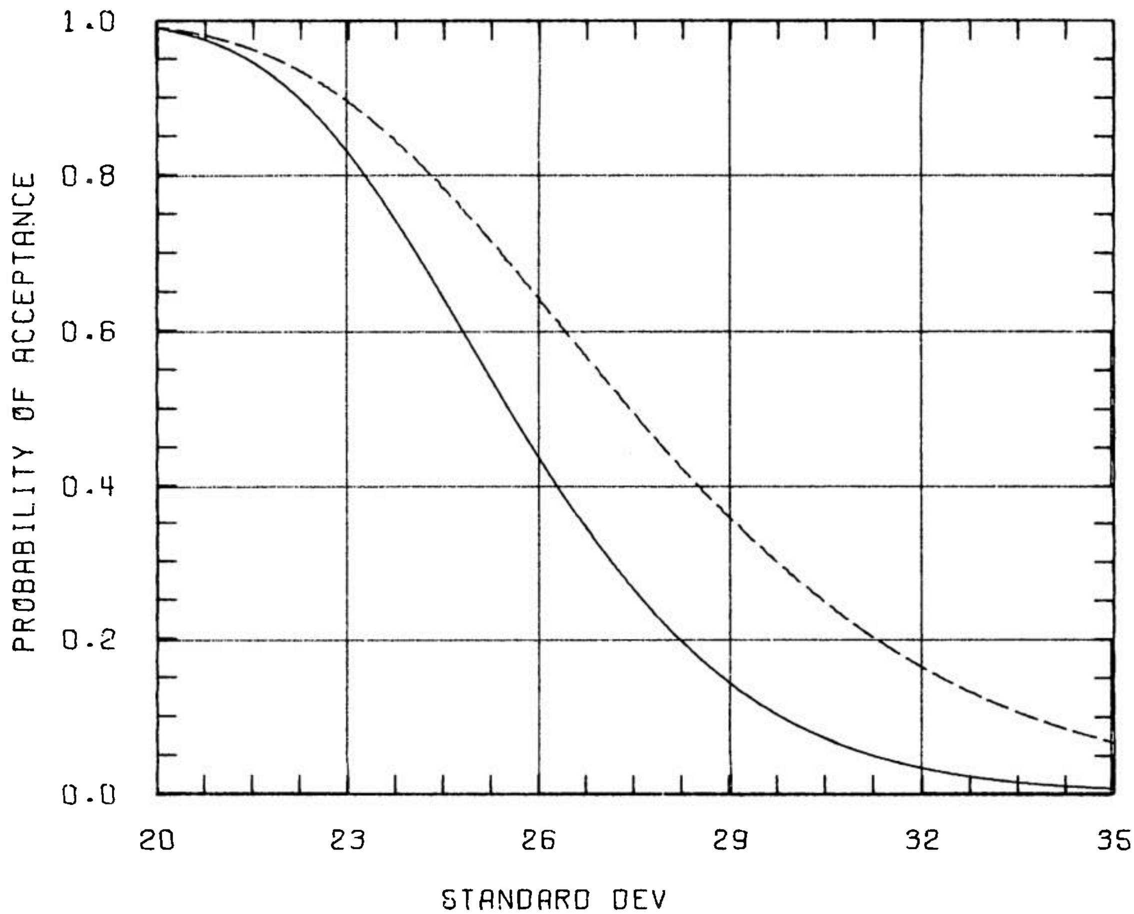
SAMPLE SIZE	FAILURES ALLOWED	LINE TYPE
80	3	————
48	3	– – – –

IV. HE M374A2/A3 Cartridges

A. Defect Type - Range standard deviation low charge

B. Sampling Plan - First three lots of a contract sample 40/lot, then 24/lot (reduced level only if first three lots are accepted)

C. Acceptance Criterion - Sample standard deviation times a factor is less than 20 m.



O C CURVES STANDARD DEVIATION TEST

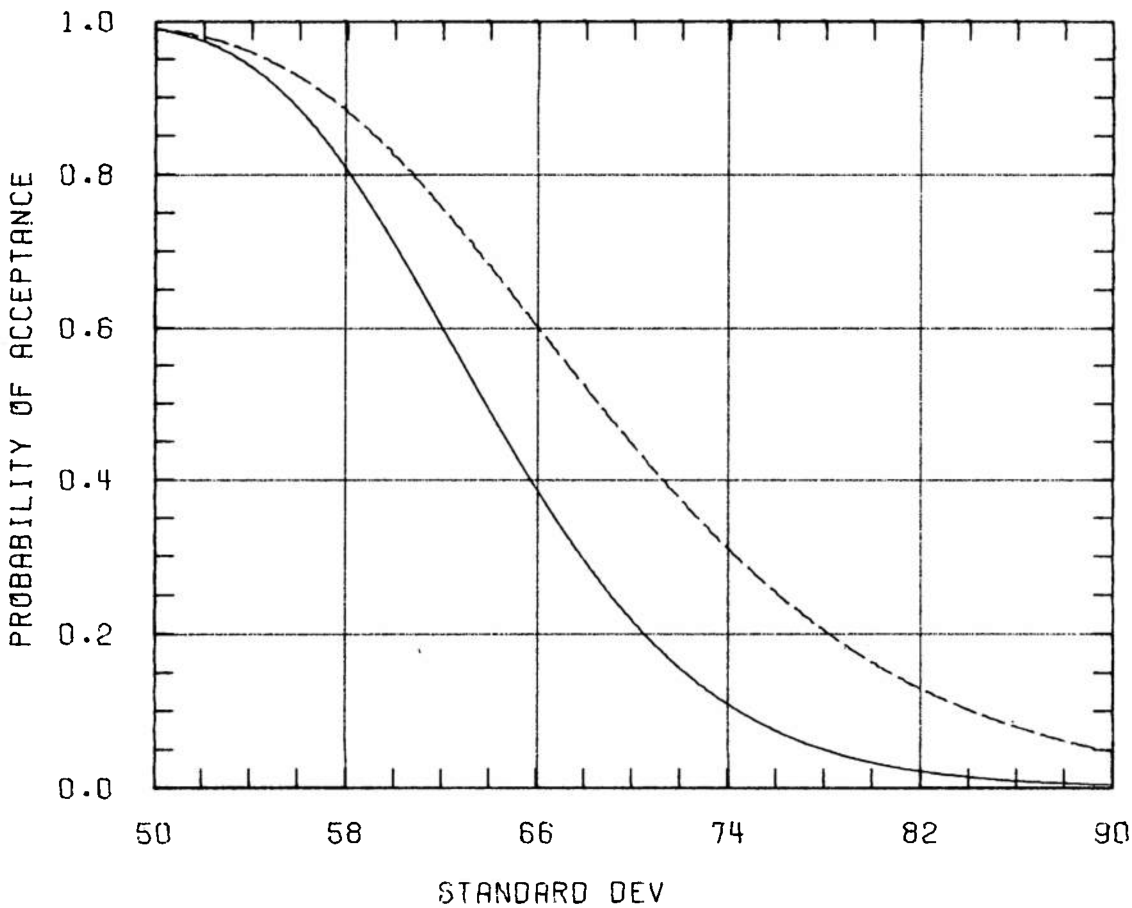
SAMPLE SIZE	REQUIREMENT	LINE
40	20	————
24	20	– – – – –

V. HE M374A2/A3 Cartridges

A. Defect Type - Range standard deviation high charge

B. Sampling Plan - First three lots of a contract sample 40/lot, then 24/lot (reduced level only if first three lots are accepted)

C. Acceptance Criterion - Sample standard deviation times a factor is less than 50 m.



O C CURVES STANDARD DEVIATION TEST

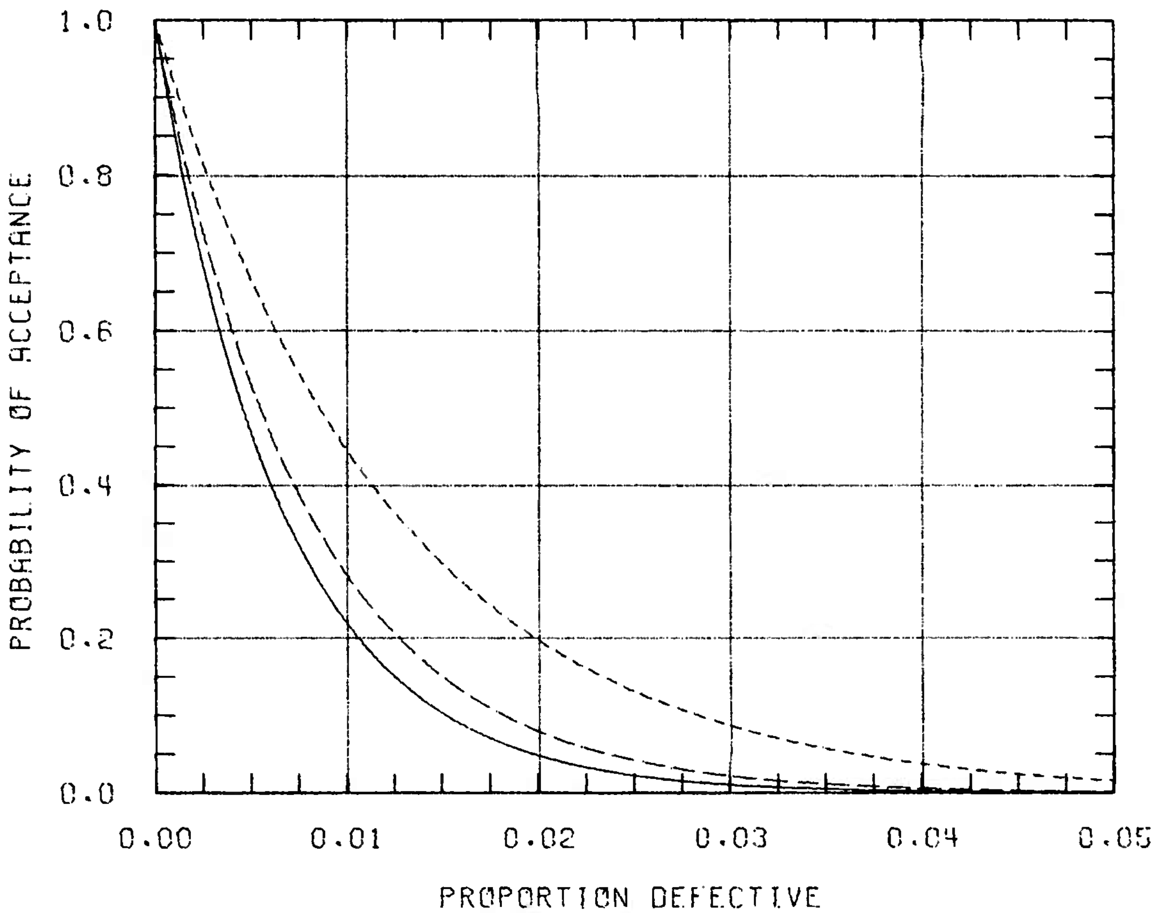
SAMPLE SIZE	REQUIREMENT	LINE
40	50	————
24	50	– – – – –

VI. M524A6/M567 Fuzes

A. Defect Type - Prematures

B. Sampling Plan - For M524A6 Fuze, sample 150/lot. For M567 Fuze, sample first three lots of a contract at 125/lot and then 80/lot (reduced level only if first three lots are accepted)

C. Acceptance Criterion - No defects



O C CURVES BINOMIAL DISTRIBUTION

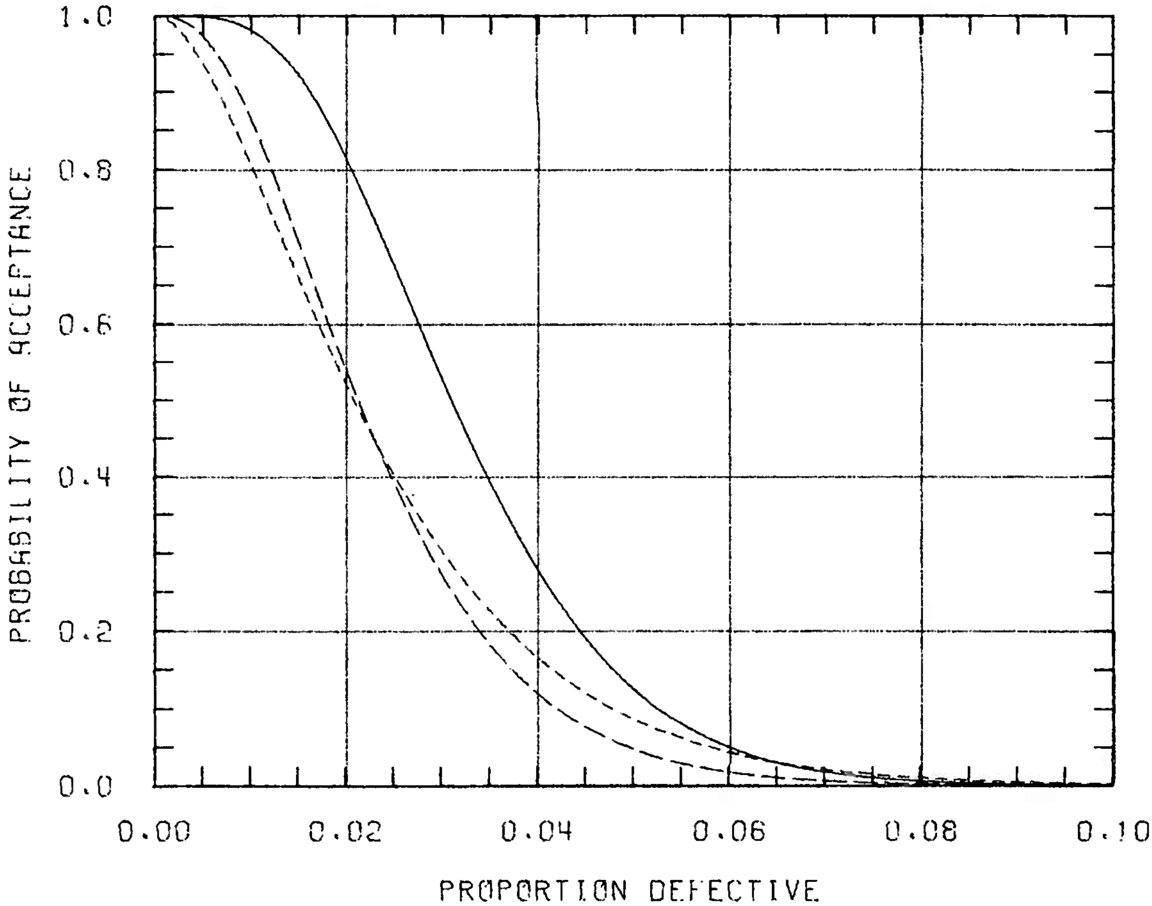
SAMPLE SIZE	FAILURES ALLOWED	LINE TYPE
150	0	————————
125	0	— — — — —
80	0	- - - - - - -

VII. M524A6/M567 Fuzes

A. Defect Type - Duds

B. Sampling Plan - For M524A6 Fuze, sample 150/lot. For M567 Fuze, sample first three lots of a contract at 125/lot and then 80/lot (reduced level only if first three lots are accepted)

C. Acceptance Criterion - For M524A6 Fuze, four defects. For initial M567 Fuze sample, two defects. Follow-on M567 Fuze sample, one defect.



O C CURVES BINOMIAL DISTRIBUTION

SAMPLE SIZE	FAILURES ALLOWED	LINE TYPE
150	4	————
125	2	— — — —
80	1	- - - - - -

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